ENVIRONMENTAL ENERGY
TECHNOLOGIES DIVISION

Summary of Workshop:

Barriers to Energy Efficient Residential Ventilation

Held on January 10, 2008

Max Sherman (MHSherman@lbl.gov)

DISCLAIMER[1]

[1] This work was supported by the Assistant Secretary for Energy Efficiency and Renewable Energy, Office of Building Technology, State, and Community Programs, of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

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Introduction

The purpose of this Building America workshop was to bring together a few interested participants to discuss the issues associated with implementing energy efficient ventilation in homes. The workshop was held on January 10 at DOE Headquarters and the following people attended:

Attendance List

The workshop participants represented a wide range of interests:

- **Building America Teams**
  - **BIRA, IBACOS, CARB, IHP, BSC**
- **Industry**
  - **HVI, Panasonic, Fantech**
- **Labs**
  - **NREL, NIST, ORNL, LBL**
- **Federal Agencies**
  - **DOE, EPA**

The following people gave presentations at the workshop

- **John Talbott**
- **Steve Emmerich**
- **Bob Hendron**
- **Srikanth Puttagunta**
- **Subrato Chandra**
- **Joe Lstiburek**
- **Ola Wettergren**
- **Don Stevens**
- **Eric Werling**
- **Jeff Christian**

The remaining people also attended

- **Bruce Baccei**
- **Duncan Prahl**
- **Steve Bolibruck**
- **Brad Oberg**
- **David Springer**
- **Ron Judkoff**
- **Margo Thompson**
- **David Price**
- **Terry Logee**
- **George James**
- **James Lyons**

Background

The purpose of ventilation is to provide fresh (or at least outdoor) air for comfort[2] and to ensure healthy indoor air quality by diluting contaminants. Historically, people have ventilated buildings to provide source control for combustion products, objectionable odors and to control high indoor moisture generation. Currently, a wide range of ventilation technologies is available to provide ventilation in dwellings including both mechanical systems and more sustainable technologies. Most of the existing housing stock in the U.S. uses infiltration combined with window opening to provide ventilation. Sometimes this results in over-ventilation with subsequent energy loss or under-ventilation and potentially poor indoor air quality. Recent residential construction methods have created tighter, less energy-consuming building envelopes that create a potential for under-ventilation. Infiltration rates in these new homes average a third to a quarter of the rates in existing stock. As a result, new homes often need mechanical ventilation systems to provide acceptable indoor air quality or to meet current ventilation standards.

Because of the effects it has on health, comfort, and serviceability, indoor air quality in homes is becoming of increasing concern to many people. According to the American Lung Association a number of factors within our homes have been increasingly recognized as threats to respiratory health. The Environmental Protection Agency lists poor indoor air quality as one of the largest environmental threat to our country. Asthma is the leading serious chronic illness of children in the U.S. Construction-defect litigation and damage are on the increase in new houses and some of this increase is related to indoor air quality problems such as moisture. Residential ventilation can address many of these indoor air quality problems.

Traditionally residential ventilation was not a major concern because policy makers believed that, between operable windows and envelope leakage, people were getting enough outdoor air. However, recent research has shown that these days the majority of occupants do not open windows sufficiently from the point of view of satisfying ventilation requirements, such as ASHRAE 62.2. ASHRAE is in the process of publishing an addendum to ASHRAE 62.2 removing the exception allowing operable windows to meet the whole-house mechanical requirements. Over the past three decades, houses have become much more energy efficient. At the same time, the types of materials used in furniture, appliances, and building materials in houses have changed. People have also become more environmentally conscious, not only about the resources they were consuming but about the environment in which they live.

ASHRAE Standard 62.2 is a standard for ventilation for acceptable indoor air quality in low rise residential buildings that (together with its companion Standard 62.1 for all

[2] Comfort in an IAQ context means acceptable perceived air quality and not principally thermal comfort. This includes control of irritating substances and objectionable odors.

other buildings) represents the current standard for setting ventilation rates. Like all ASHRAE standards 62.2 is continually updated with the next version expected to be published in 2010.

ASHRAE Standard 62.2 has requirements for whole-house ventilation, local exhaust ventilation, source control, and system requirements. The standard assumes that infiltration contributes 2 cfm/100 sq. ft. (0.1 L/s/m^2) of floor area. In addition to this infiltration, the prescriptive part of the standard requires whole-house mechanical ventilation rate given by Equation 1:

$$\begin{aligned} Q(cfm) &= 0.01A_{floor}\left(ft^2\right)+7.5(N+1) \\ Q(L/s) &= 0.05A_{floor}\left(m^2\right)+3.5(N+1) \end{aligned} \qquad \textbf{(1)}$$

Where Q is the required ventilation rate, A_{floor} is the house floor area and N is the number of bedrooms. For most houses the ventilation rate requirements of Equation 1 must be met by mechanical ventilation.

Standard 62.2 also requires local mechanical exhaust in kitchens and bathrooms. Kitchens must have the capacity to exhaust at least 100 cfm (50 L/s) through a range hood or provide 5 kitchen air changes per hour. Bathrooms must have the capacity to exhaust 50 cfm (25 L/s) or have 20 cfm (10 L/s) of exhaust continuously.

Energy Efficiency

Standard 62.2 sets minimum requirements for ventilation but does not address the energy required to provide that ventilation. Infiltration and ventilation typically account for 1/3 to ½ of the space conditioning load. As houses get more efficient both the infiltration and the sensible load through the envelope get reduced.

In tight, energy efficient homes, such as those from Building America, the ventilation load becomes a larger fraction of the total load. While the ventilation load in the absolute may be substantially smaller than the infiltration load in a typical home, reducing the ventilation load becomes more and more a priority in the quest for higher efficiency levels.

A special problem exists in the more humid climates. As the sensible load decreases through better building envelopes, the latent load from both ventilation and internal sources becomes a larger and larger fraction of the total load. Conventional air conditioning equipment may not be able to handle such a low sensible-heat ratio especially during shoulder seasons.

Regardless of the climate, however, there is a need to provide whatever ventilation is deemed acceptable in an energy efficient manner. There have been various reports on how to do this with the most commonly considered systems.

Workshop Objectives

The objectives for this workshop were to bring together those with different viewpoints on the implementation of energy efficient ventilation in homes to share their perspectives. The primary benefit of the workshop is to allow the participants to get a broader understanding of the issues involved and thereby make themselves more able to achieve their own goals in this area.

In order to achieve this objective each participant was asked to address four objectives from their point of view:

- **Drivers for energy efficient residential ventilation**: Why is this an important issue? Who cares about it? Where is the demand: occupants, utilities, regulation, programs, etc? What does sustainability mean in this context?
- **Markets & Technologies**: What products, services and systems are out there? What kinds of things are in the pipeline? What is being installed now? Are there regional or other trends? What are the technology interactions with other equipment and the envelope?
- **Barriers to Implementation**: What is stopping decision makers from implementing energy-efficient residential ventilation systems? What kind of barriers are there: technological, cost, informational, structural, etc. What is the critical path?
- **Solutions**: What can be done to overcome the barriers and how can/should we do it? What is the role of public vs. private institutions? Where can investments be made to save energy while improving the indoor environment?

Ten participants prepared presentations for the workshop. Those presentations are included in sections at the end of this workshop report.

These presentations provided the principal context for the discussions that happened during the workshop. Critical path issues were raised and potential solutions discussed during the workshop. As a secondary objective we have listed key issues and some potential consensus items which resulted from the discussions.

Key Issues

A key theme that appeared repeatedly was that a major barrier was having the decision maker understand the *value proposition* for implementing energy efficient ventilation. What this value proposition is depends strongly on who the decision maker is. Builders, contractors, manufacturers, consumers and public interest groups have very different views on the costs and benefits of energy efficient ventilation.

Another broad issue was that energy efficient residential ventilation is a compound concept. That is, the case for having ventilation at all must be considered first. Once that is done the *energy efficient* aspect of it follows a similar path to other residential energy efficiency features. The most energy intensive part of ventilation requirements such as 62.2 is the whole-house mechanical ventilation because of the energy requirement to provide and, more importantly, the energy required to condition that air.

Another broad issue was that most decision makers were getting mixed messages from the "expert" community and were therefore unlikely to make substantial investments. That is, it appears to them that there is no consensus on whether to ventilate, how much to ventilate etc. and therefore there was little reason to change unless they themselves perceived a key problem.

Builders

Builders were a key group, well represented by the Building America teams present as well as NAHB. The general sense was that builders were primarily motivated to ventilate to reduce their risk. This included risks of call-backs and risk of litigation. Thus durability is part of the motivation. It was also felt that builders would respond to customer demand to provide these benefits, but that there was currently not much demand.

Builder concerns also depended on the market segment of the builders. The low-cost oriented builders would not likely implement energy efficient ventilation (or ventilation of any kind) unless required to by code. The more value-added builders would implement energy efficient ventilation if the got sufficient value through perceived quality improvements in their product. That is, if the builder had some way of showing that his product was better, met some higher quality level or was in some was differentiated he would be willing to invest in it.

Some Building America participants believe that the current 62.2 rates are too high for Building America houses in hot, humid climates. As a result their builder partners provide whole house mechanical ventilation in hot-humid climates that are significantly below the current 62.2 rates. This approach has led to low ventilation and low associated ventilation energy but very few homeowner complaints in hundreds of homes built to date with these types of positive pressure whole house ventilation system over the last decade. While the lack of complaints does not necessarily indicate acceptable IAQ, limited data suggests good RH control with this strategy. Data is lacking, however, on how such a strategy impacts contaminants such as VOCs, particulates, toxic compounds, radon, formaldehyde, etc.

Because of the infiltration credit built into 62.2 some BA participants and their builder partners view 62.2 as a barrier to building tight homes. Some groups outside of ASHRAE have interpreted the standard to mean that if the building is tighter than the default infiltration credit, the mechanical ventilation needs to be increased and/or no energy benefit can be taken. ASHRAE has formally clarified that no such thing is required, but the barrier remains.

Some also view ASHRAE Standard 62.2 as a barrier to energy-efficient ventilation because it does not properly credit the performance differences among various mechanical ventilation systems. For example, balanced systems (e.g. Heat Recovery Ventilators) interact differently with the building than do unbalanced systems (e.g. continuous supply). Similarly systems that distribute the air differently (e.g. fan integrated systems vs. single point exhaust) should in principle provide different levels of performance.

The issues raised above of contaminants of concern, energy efficient humidity control, minimum rates, the role of infiltration, air distribution impacts, and system interactions are all open issues requiring further investigation before they can be reliably adopted by builders.

Consumers

It was felt that few consumers understood the issues associated with ventilation and indoor air quality enough to make informed choices and therefore to supply demand for the market. Consumers may generally assume that health concerns are already provided by any house they buy in the same way the structural safety concerns are taken care of. Many consumers apparently believe that when they are told they have an "HVAC" system, they actually get ventilation.

There was a general belief that consumers would want good indoor air quality and good ventilation, but did not know what that meant or how to ask for it. From the consumer standpoint ASHRAE Standard 62.2 is enabling because it specifies minimum ventilation. Unless codes require the use of 62.2, however, consumer education is needed for them to be able to actually get energy efficient ventilation.

Manufacturers / Ventilation Industry

The manufactures were represented by two past chairman of the Home Ventilating Institute each also presenting their own companies. The manufacturers of ventilation products have been developing appropriate equipment for the change in the market. Many more products are available to meet the sound and air flow requirements of ASHRAE Standard 62.2 The industry felt that the rates of ASHRAE Standard 62.2 were too low based on medical studies and supports a higher mechanical ventilation rate.

A key industry issue is getting good information into hands of decision makers including consumers. This information includes the value of IAQ and the associated need for ventilation as well as the different implications of meeting these needs in different ways. The industry felt was capable of providing systems and equipment information to its customers.

Public Sector

DOE, EPA and the National Labs represented the public sector. The public sector was seen as being the best able to answer R&D questions regarding minimum requirements and system performance. The public sector also is the key player in setting performance specifications that would allow labeling or certification or other means of allowing the market to show that particular pieces of equipment and/or systems could provide value. The public sector could play a role of facilitator and independent third party.

From the public health perspective of organizations such as EPA, it is not surprising that improving RH control, in highly controlled homes in hot, humid climates has led to fewer comfort complaints, since odors and RH are the most common comfort complaints. However, there are many pollutants (e.g. formaldehyde, other VOC's, radon, ozone) that will not be controlled by this strategy, pose significant long term health risks, and which are often characterized by the lack of symptoms that can be easily discerned as comfort issues. The focus on reducing ventilation rates to allow effective RH and odor control in hot/humid climates is at best a partial and temporary solution. It may reduce comfort complaints (and some RH related health risks), while ignoring, and very likely increasing other health risks that are not being measured. Furthermore, reducing ventilation air is only one way of tackling the RH problem in hot/humid climates. Dehumidification is a viable strategy for controlling indoor humidity that does not sacrifice other aspects of indoor air quality. Like ventilation, humidity control is a building service that may require energy and so energy-efficient options must be explored.

Summary and Recommendations

The participants did not have time to come to consensus on specific recommendation, but the list below reflects recommendations coming from multiple sources at the workshop.

- Builders need simple, preferably single, solutions that are easily implementable
- More research is needed on the ventilation science, looking at minimum requirements, contaminants of concern (including humidity), regional issues and exposure. Much of the data justifying higher ventilation rates have come from Scandinavian countries. This may not be applicable to hot-humid climates where high vent rates can cause high humidities and dust mites and mold and other IAQ

problems. What is the right vent rate that optimizes energy usage, eliminates moisture problems and keeps VOCs to acceptable levels?

- 3rd party labels or ratings should be developed/expanded to facilitate evaluation and implementation of energy efficient strategies
- Risk assessment and IAQ analyses should be done evaluating moisture as a pollutant. This could be extended to other outdoor air contaminants as well.
- To address barriers and other key issues mentioned above, several areas of work relating to ASHRAE Standard 62.2 (or similar codes and standards) were identified as needing further development:
    - Trade-offs between minimum ventilation rate and air distribution systems
    - Role of infiltration
    - Minimum rates
    - Role of air cleaning/filtration
    - Material emission reduction (e.g. low emission furnishings)
    - Regional requirements
    - Alternative compliance mechanisms including "the IAQ method" of 62.1
    - Differences between new and existing homes
- A significant recommendation of the group was the need for a study to determine the relationship between contaminant levels, ventilation rates and house properties. Such a study would be large in scope and likely involve several institutions so that energy, indoor air quality, cost and sustainability concerns could be properly addressed.
- Another recommendation was to look at moisture as a special kind of contaminant. Moisture is special because a) for hot humid climates is both indoor and outdoor, b) it can be a comfort problem when too high or too low, c) it is not itself a contaminant but can enable contamination when it allows materials to become too damp, d) it has a special kind of "air cleaning" in the form of AC operation and/or dehumidification.

The workshop provided an excellent venue to exchange information regarding the implementation of energy efficient residential ventilation. The net outcome was felt to be positive and worth repeating. It was generally felt that any future such workshop would benefit from more input from the indoor air quality community.

While much of this workshop is generally applicable to most residential occupancies, the focus was on new, single-family homes. Issues specific to HUD-code homes, multifamily buildings, or existing homes were not discussed in any significant way.

Presentation by John Talbott

Role of ASHRAE Standards in Energy Efficient Residential Ventilation

John M. Talbott PE
ASHRAE Member
Talbott Consulting

Discussion

- Standards can be both drivers and barriers
- ASHRAE Standards landscape (handout) includes segmentation of purposes
- Critical segmentation is energy conservation vs. IAQ i.e., ASHRAE 90.2 vs. 62.2. A “no more than” standard vs. a “no less than” standard.

Discussion

- It is dysfunctional for a “no more than Standard” to recommend a level below the “no less than Standard”
- A “no more than Standard” should not offer “no less than levels”
- There should be some distance between the no less than level and the no more than level.

Other ASHRAE Standards

- **136 Residential Air Change: is subsumed into 62.2**
- **119 Residential Leakage Standard could be subsumed? Maybe not**
- **119 is an Energy Conservation Standard with due consideration of IAQ**
- **“After-build compliance” is an issue with 119**
- **New revision committee for 119**
- **The hope for Standard189 Sustainable Buildings**

SUMMARY

- Many Standards relate/contribute to the objective of energy efficient ventilation.
- Although segmentation of purposes is inevitable, development of consensus on each purpose is still important
- Drivers are not in place to allow standards to deliver EERV. (as compared to SEER 13)

ASHRAE 62.2 Residential

- Generally lower ventilation requirement.
- Infiltration is credited in two ways:

Default credit:

$$V_{OA\ 62.2} = \mathbf{7.5\ (Nbr +1) + 0.01\ A}$$

and excess credit

$$V_{OA\ 62.2} - \tfrac{1}{2}(\text{Measured Leakage - } 0.02\ A)$$

ASHRAE 62.2 Residential

- Intermittent Operation

$$Q_f = Q_r/(ef)$$

Where

Q_f = fan flow rate
Q_r = ventilation air requirement (from Table 4.1)
e = ventilation effectiveness (from Table 4.2)
f = fractional on-time.

ASHRAE 62.2 Mass Continuity Effects

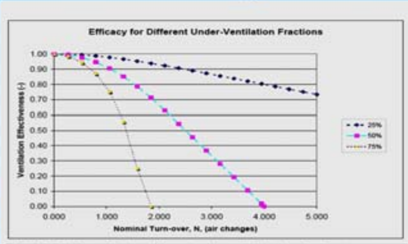


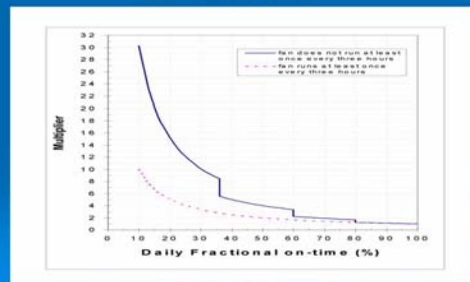
FIGURE 1: Efficacy for three different under-ventilation time fractions as a function of nominal turn over.

ASHRAE 62.2 Residential

TABLE 4.2 Ventilation Effectiveness for Intermittent Fans

Daily Fractional On time, f	Ventilation Effectiveness, e
f<= 35%	0.33
35% <= f < 60%	0.50
60% <= f < 80%	0.75
80% <= f	1.0
If fan runs at least once every three hours e = 1.0	

ASHRAE 62.2 Graphical Representation of Intermittent Fan Allowance



ASHRAE 62.2 Single and Multiple Fan Scenarios

Scenario	Fan#1 actual cfm (creditable cfm)	Fan #2	Fan #3	Total
One 60 cfm continuous fan	60 (60)			60
Two 30 cfm continuous fans	30 (30)	30 (30)		60
One 120 cfm intermittent fan @ 50% runtime, controlled to operate every three hours	120 (60)			60
One 240 cfm intermittent fan @ 50% runtime, no cycle control	240 (60)			60

ASHRAE 62.2 Multiple Fans

Scenario	Fan#1	Fan #2	Fan #3	Total towards requirement
Two 60cfm intermittent fans each @ 50% runtime, controlled to operate once every three hours	60 (30)	60 (30)		60
Two 120 cfm intermittent fans each @ 50% runtime, no cycle control	120 (30)	120 (30)		60
One 55 cfm continuous, two local 100 cfm, 50cfm, deemed to run 10% no cycle control	55 (55)	100 (3.3)	50 (1.6)	60

ASHRAE 62.2 2007 proposed addendum

Fractional On-Time	Cycle Time (hours) 0 to 6	8	12	24
0.1	10.0	11.5	15.4	*
0.2	5.0	5.6	6.6	*
0.3	3.3	3.6	4.0	*
0.4	2.5	2.6	2.8	5.4
0.5	2.0	2.1	2.2	2.9
0.6	1.7	1.7	1.8	2.1
0.7	1.4	1.4	1.5	1.6
0.8	1.3	1.3	1.3	1.3
0.9	1.1	1.1	1.1	1.1
1.0	1.0	1.0	1.0	1.0

ASHRAE 136 Effective Air Change for Residential

A_{Ei} = (Balanced Fan Flow + ((Infiltration Flow)^2 +(Unbalanced Fan Flow)^2)$^{0.5}$

$$A_E = 8760/[\sum_{i=1}^{n}(\tau_i / A_{Ei})]$$

where
tau = the time per year for which the particular combination of operating fans used to calculate AEi was in effect (hours per year), and
n = the number of time periods in the year with different values of AEi.

ASHRAE 136 Fan Addition

Scenario	Measured infiltration	Fan #1	Fan #2	Total
No Fan	50			50
One unbalanced 100 cfm 10% runtime	50	100		56.2
One balanced 100 cfm 10% runtime	50	100		60
Two unbalanced fans 100 cfm, 50 cfm, 10% runtimes	50	100	50	59.5
Two fans one 100 cfm balanced, 50 cfm unbalanced, 10% runtime for both	50	100	50	62

Summary and Conclusions

- When does two plus two equal four? Nearly never.
- Why are there different Mathematical Expressions across these Standards?
  62.1 vs. 62.2 (appropriate differences)
  62.2 vs. 136 (different perspectives)
- Are all these differences the end of the world? No

Presentation by Steve Emmerich

ASHRAE STANDARD 62.2-2007

Ventilation and Acceptable Indoor Air Quality for Low-Rise Residential Buildings

Steven J. Emmerich
Chair, ASHRAE SSPC 62.2
January 2008

INTRODUCTION

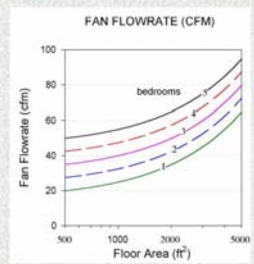
- **Purpose** This standard defines the **roles** of and **minimum requirements** for mechanical and natural **ventilation systems** and the **building envelope** intended to **provide acceptable indoor air quality** in low-rise residential buildings.
- **Scope** Single-family houses and multi-family structures of three stories or fewer

PRIMARY REQUIREMENTS

- Whole Building Ventilation
  - Mechanical system meeting Section 4 or "other methods" when approved by LDP
- Local Exhaust
  - Fans in Kitchens and Baths
- Other Requirements
  - Limited Source Control
- Air-Moving Equipment
  - Sound and other requirements

MECHANICAL VENTILATION REQUIREMENT

- Limited Exceptions
- Control System
- Intermittent Operation Permitted
- Climate-Based System Restrictions
- Includes a Default Infiltration Credit (2 cfm/100 sq. ft.)



2 cfm =1 l/s   10 ft²=1 m²

LOCAL EXHAUST

- **Kitchens**
  - 100 cfm (50 l/s) capacity or
  - 5 h^{-1} continuous
- **Bathrooms**
  - 50 cfm (25 l/s) capacity or
  - 20 cfm (10 l/s) continuous

OTHER REQUIREMENTS

- No Transfer Air from Adjacent Units, Garages, etc.
- Instructions & Labeling
- Clothes Dryers: Exhausted to Outside
- Net Exhaust Limit for Combustion Appliances
- Air Handlers in Garages Must be Sealed
- Windows for Additional Ventilation Capacity Minimum Filtration
- Ventilation Openings

AIR-MOVING EQUPMENT

- Sound ratings
- Airflow ratings
  - Duct sizing or flow measuring
- Dampers in Multi-Branch Exhaust Ducting

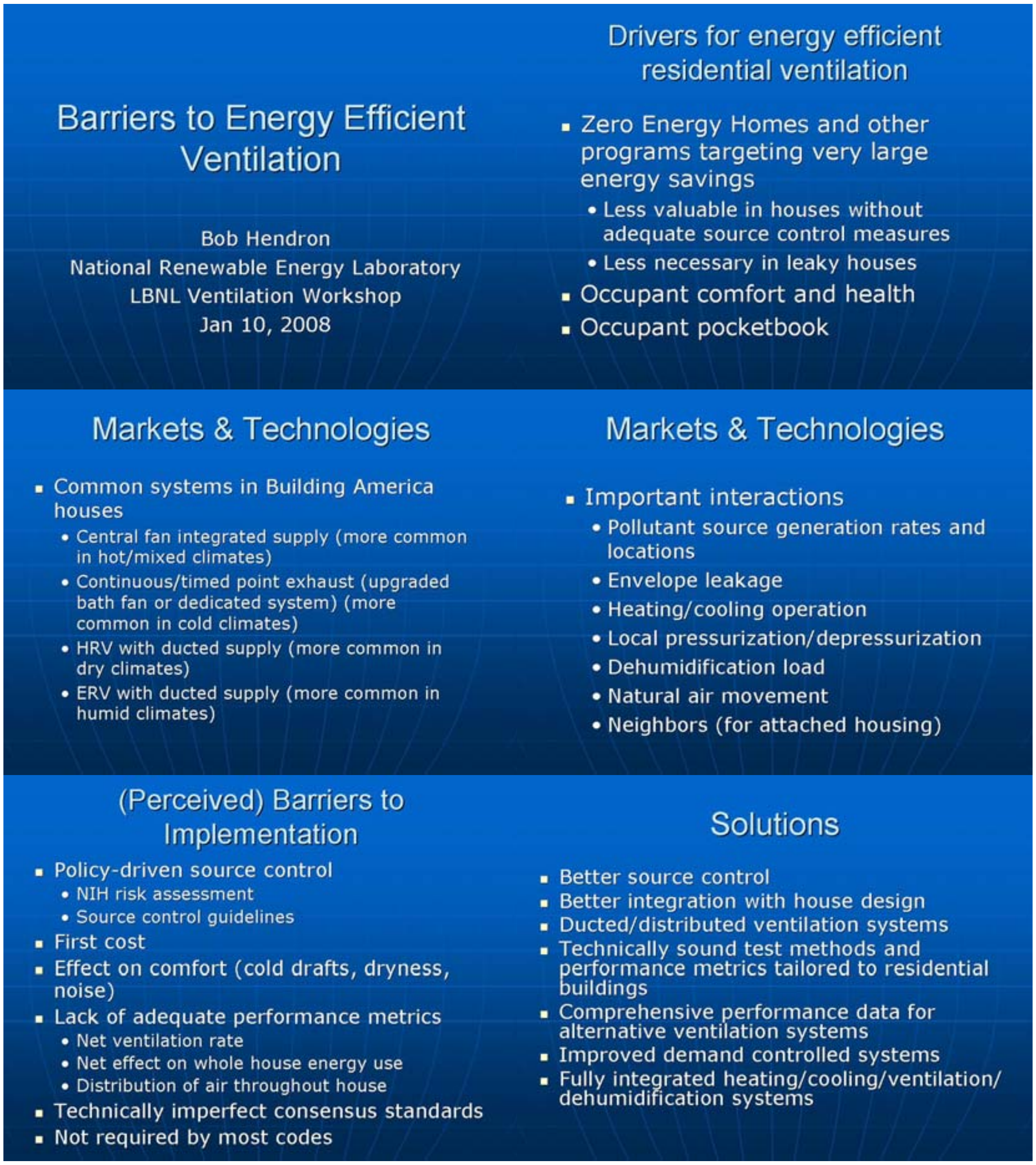
Other 62.2 stuff

- *Appendix A*: Operations and Maintenance
- *Appendix B:* HVAC Systems
- User's Manual for 62.2-2004 (to be revised)
- Companion Guideline 24P – completed first public review with minimal comments

Barriers to Implementation of Energy Efficient Residential Ventilation

- Standard 62.2 **is** a driver for residential ventilation.
  - Via codes/green programs
- Is it a barrier to **energy efficient** residential ventilation?
  - Energy efficiency not in scope
  - Very modest ventilation rates
  - Allows intermittent
  - Contains very few limitations on system type
  - Does not credit 'better systems'
  - Assumes a default infiltration but no tightness requirement
  - Allows "alternative ventilation" but has no specifics for natural ventilation

Presentation by Bob Hendron



Presentation by Srikanth Puttagunta

HOME VENTILATION
Balancing Energy Use and IAQ

Building America 1st Quarterly Meeting 2008
Residential Ventilation Workshop

Steven Winter Associates, Inc.

Drivers for energy efficient residential ventilation

Why is it important?
- prevent sick building syndrome as homes are built tighter and tighter

Where is the demand?
- certification programs, such as
  - Energy Star (NYSERDA)
  - LEED for Homes
  - Florida Green Home Standard
  - EarthCraft Homes
  - Healthy Homes
- increase in asthmatic children

What does sustainability mean in this context?
- sustaining a person's health rather than sustaining the built environment.

Steven Winter Associates, Inc.

What's out there?

Strategies:
- exhaust only
  - exhaust fan with control or continuous
- supply only (AHU integrated)
  - Aircycler or Honeywell Y8150
- balanced (AHU integrated or dedicated)
  - Heat Recovery Ventilator (HRV)
  - Energy Recovery Ventilator (ERV)

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What are regional trends?

Trends primarily based on cheapest option while accounting for humidity levels as moisture can contribute to health problems associated with mold, moisture can seep into the walls and woodwork causing dry rot and other structural problems, and moisture can lead to musty odors and condensation in walls and on windows.

Colder climates: typically exhaust only

Humid climates: typically supply only or ERV

Mixed climates: typically exhaust only or HRV

Canada: requires that a ventilation system be installed in every new dwelling. HRVs have become most popular due to the requirement that there be a method of introducing replacement air.

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Barriers to Implementation

Exhaust Only

pros: simple, low cost, low energy
(Panasonic WhisperGreen 50 cfm fan - 4.8 W)

cons: not distributed (for larger homes), forced infiltration, shouldn't be use if the home contains atmospheric heating equipment or wood stoves.

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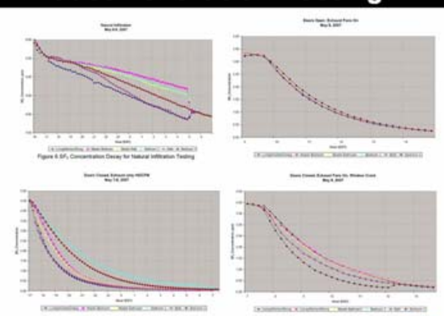
Exhaust Ventilation Testing



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Barriers to Implementation

Supply Only

pros: well distributed

cons: energy cost, energy usage highly dependent on AHU motor

Balanced

pros: heat recovery, humidity control

cons: first cost, maintenance

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Solutions

Better exhaust fans

Panasonic WhisperGreen
- SmartFlow™ Optimum CFM Technology — allows the fan to operate at a constant CFM regardless (to an extent) of the ducting of the exhaust
- DC Motor Technology — creates a motor that is 75% - 400% more energy efficient than the minimum ENERGY STAR ® requirements
- CustomVent™ Variable Speed Control — allows the fan to run at a lower level until required to elevate to a maximum level when the switch is turned on. A delayed off timer returns the fan to the minimum CFM level after a period of time set by the user.

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Solutions (cont'd)

Ventilation control based on an indicator (CO_2) rather than or in addition to ASHRAE 62.2, which prescribes rates based on a combination of experimental data, psychological considerations, subjective evaluations and professional judgment.

ERVs with ECM motors.

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Building America Research

A side-by-side comparison of three ventilation strategies in Chicago, IL

Energy Recovery Ventilation

Air Cycler Supply Ventilation

Exhaust-Only Ventilation (2 bathrooms)

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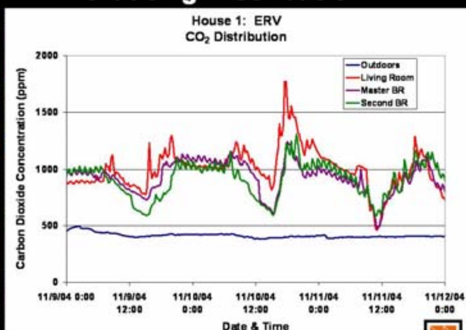
Evaluating Distribution



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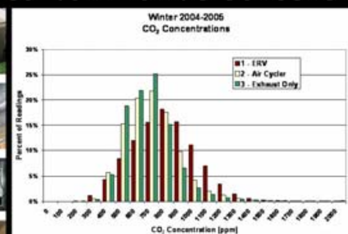
Carbon Dioxide Concentrations



Ranges in CO_2 Concentrations [ppm]

Month	1 - ERV Avg. Range	1 - ERV Median Conc.	2 - Air Cycler Avg. Range	2 - Air Cycler Median Conc.	3 - Bath Exhst Avg. Range	3 - Bath Exhst Median Conc.
Nov	124	798	60	646	160	659
Dec	120	749	85	674	83	565
Jan	132	724	102	633	79	609
Feb	129	753	95	631	88	615
Mar	150	743	93	645	88	601
Apr	185	713	77	601	164	649
Avg	140	747	87	636	110	616

Steven Winter Associates, Inc.

Ventilation Power Consupmtion

The installed furnace fans consumed 712 Watts! CARB recommended an ECM motor fan for the study, but the builder didn't install it. Results presented here show the 712 W of the AHU reduced to 250 W for a typical ECM motor unit. ERV was connected to the AHU fan to provide distribution of ventilation air.

House 1 (ERV): 814 W → 352 W

House 2 (AirCycler): 712 W → 250 W

House 3 (Exhaust only): 45 W

Steven Winter Associates, Inc.

'What If' - Efficient Air Handlers

Strategy	Electricity kWh/yr	Gas Therms/Yr	Total Ventilation Cost
ERV + Air Handler	4309/1899	-51/-9	$398/$184
Air Cycler	3714/1304	12/54	$379/$165
Exhaust Only	263	76	$76
ERV, No Air Handler	595	13	$68

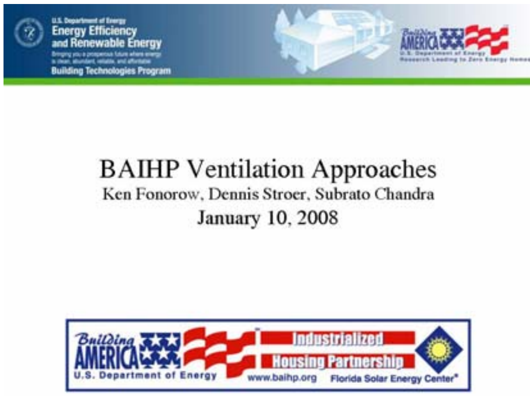
Steven Winter Associates, Inc.

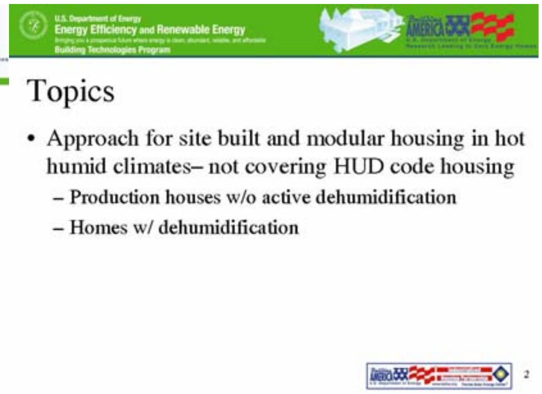
Conclusions

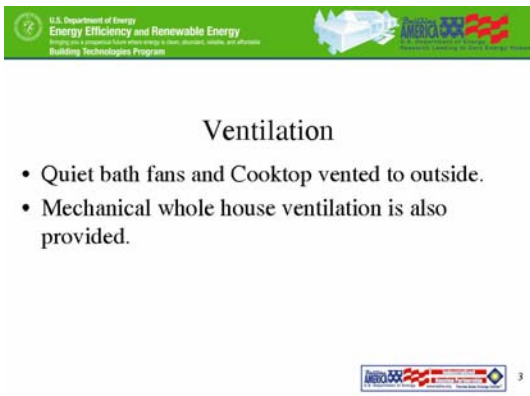
- All systems provided similar fresh air distribution.
- Exhaust-Only strategy cost 50% less to operate – with lowest first cost
- Hypothetical ERV with separate ductwork is most efficient – with highest first cost
- Need to check actual flow of systems (flows often <50% of rated flows) and check controls (timer settings & other specialized controls)

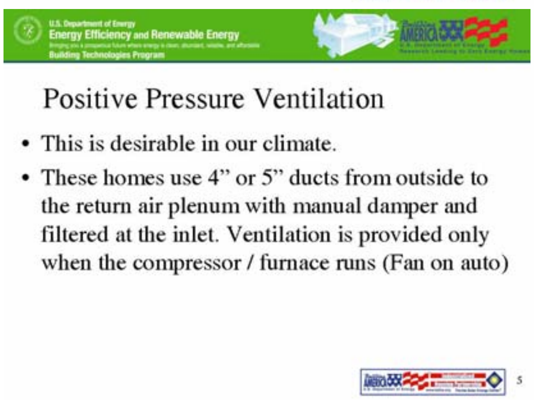
Steven Winter Associates, Inc.

Presentation by Subrato Chandra









OA Intake from back porch

Filter Backed Grill Covering the OA Intake

OA Intake Duct in Soffit

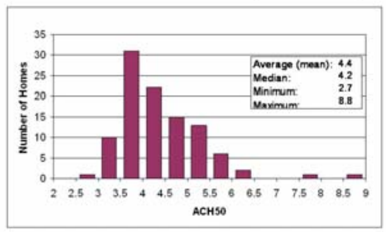
Great Location for OA Intake is ceiling of entry porch

OA Duct connection to Return Air Plenum

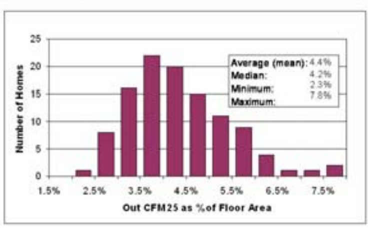
Inspect, Test, Rate

- Perform Periodic Site Inspections, Tests And Rate Each Home (~HERS 60 to 70)
- Provide Feedback To Builder
- Qualifies for $2,000 federal tax credit

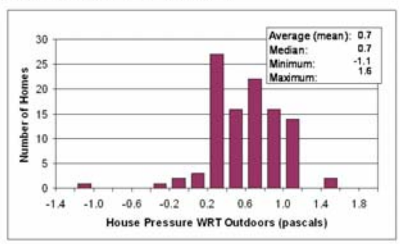
Data from 102 houses (ACH50)



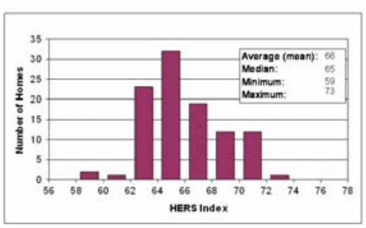
Duct Leakage to Outside



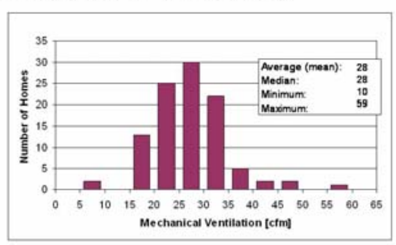
House Pressurization



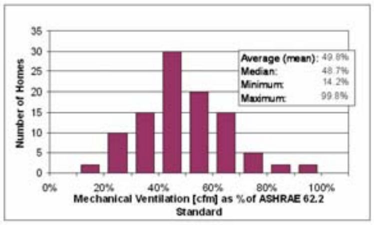
HERS Index



Whole House Vent Rate



Vent Rate as % of 62.2

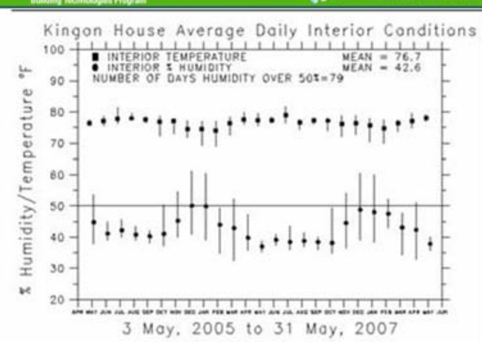


Notes

- Provided ventilation =runtime*vent rate + kitch and bath vent+dryer vent + operable windows. Total has not been measured in these homes.
- In over 500 homes with this type of ventilation system no reported complaints about odor
- Interior T and RH Data on ~100 homes is planned this year , 50 BA and 50 non BA
- Data from one home in Ft. Myers area (south FL) next

T and RH data for New Generation Homes by Kingon

- 2481 sq. ft.- family of 4
- No zoning
- 32 cfm runtime vent
- Vented attic
- Ft. Myers, FL



Homes with Dehumidification

- Stalwart Homes, Panama City, North FL
- Palm Harbor Home Prototype, Siesta Key, South FL

StalwartBuilt HOMES
beyond green

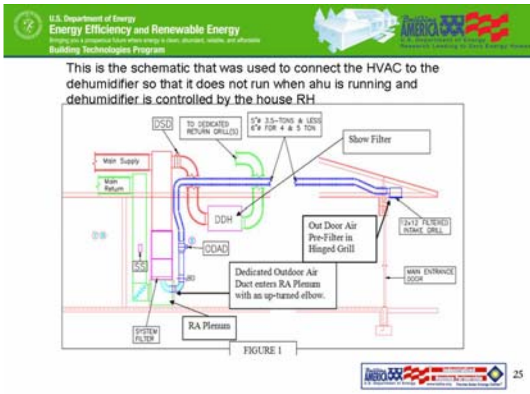
Location	Callaway, FL
Number of Homes	270/ 10 to date
HERS Index (PV / no PV)	27 / 60
Benchmark (PV / no PV)	69% / 46%
Green Program	LEED

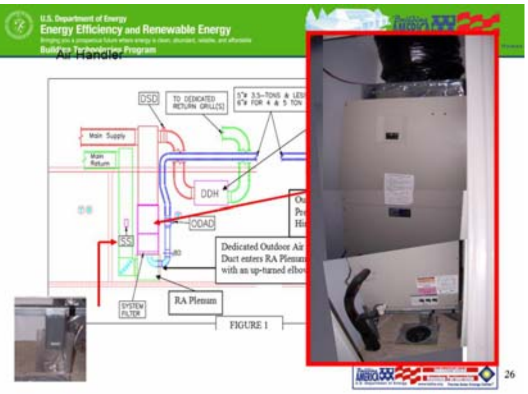
Factory built modular houses, geothermal HVAC with heat recovery water heater, ducts in conditioned space, runtime vent w/ dehumidifier, unvented attic, vented crawlspace, 1 with 3.6 kW PV

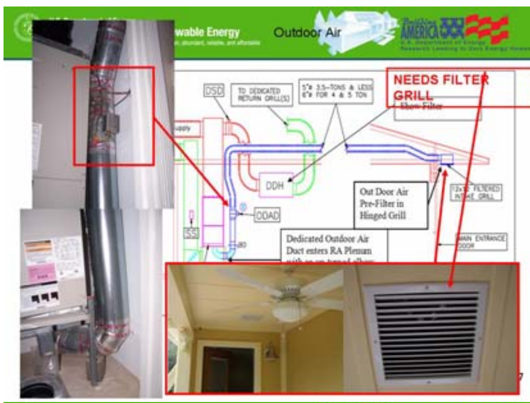
PHH Gen-X Solaro IBS 2007 Home

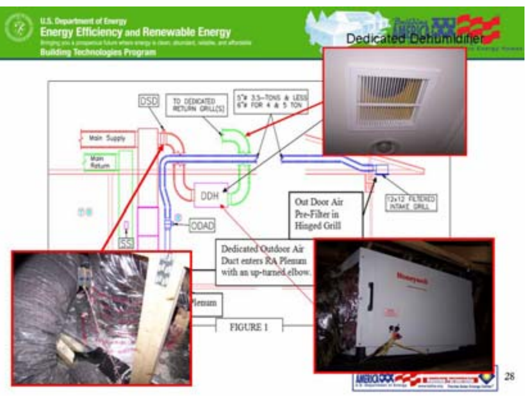
Site Relocation to Siesta Key, FL

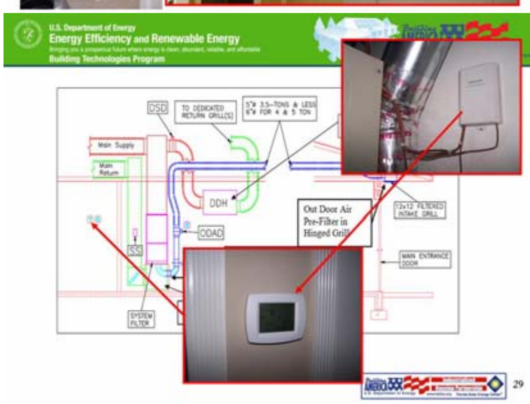
Solar panels (PV and DHW) on the south roof.

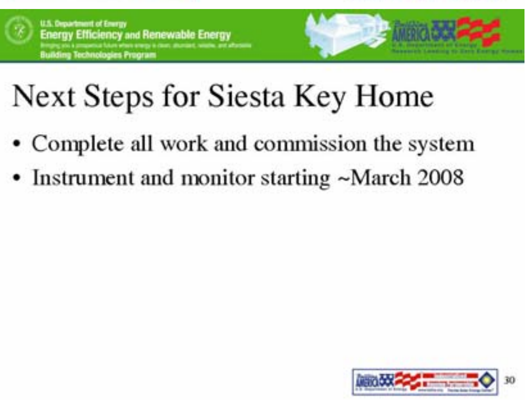

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Building Technologies Program
This is the schematic that was used to connect the HVAC to the dehumidifier so that it does not run when ahu is running and dehumidifier is controlled by the house RH
DSD
TO DEDICATED RETURN GRILL(S)
5"Ø 3.5–TONS & LESS
6"Ø FOR 4 & 5 TON
Show Filter
Main Supply
Main Return
DDH
Out Door Air Pre-Filter in Hinged Grill
12x12 FILTERED INTAKE GRILL
ODAD
SS
Dedicated Outdoor Air Duct enters RA Plenum with an up-turned elbow.
MAIN ENTRANCE DOOR
SYSTEM FILTER
RA Plenum
FIGURE 1
25


U.S. Department of Energy
Energy Efficiency and Renewable Energy
Building Technologies Program
Air Handler
DSD
TO DEDICATED RETURN GRILL(S)
Main Supply
Main Return
DDH
ODAD
SS
Dedicated Outdoor Air Duct enters RA Plenum with an up-turned elbow.
SYSTEM FILTER
RA Plenum
FIGURE 1
26


Outdoor Air
NEEDS FILTER GRILL
DSD
TO DEDICATED RETURN GRILL(S)
5"Ø 3.5–TONS & LESS
6"Ø FOR 4 & 5 TON
DDH
Out Door Air Pre-Filter in Hinged Grill
ODAD
SS
Dedicated Outdoor Air Duct enters RA Plenum
MAIN ENTRANCE DOOR


U.S. Department of Energy
Energy Efficiency and Renewable Energy
Building Technologies Program
Dedicated Dehumidifier
DSD
TO DEDICATED RETURN GRILL(S)
5"Ø 3.5–TONS & LESS
6"Ø FOR 4 & 5 TON
Main Supply
Main Return
DDH
ODAD
SS
Out Door Air Pre-Filter in Hinged Grill
12x12 FILTERED INTAKE GRILL
Dedicated Outdoor Air Duct enters RA Plenum with an up-turned elbow.
FIGURE 1
28


U.S. Department of Energy
Energy Efficiency and Renewable Energy
Building Technologies Program
DSD
TO DEDICATED RETURN GRILL(S)
5"Ø 3.5–TONS & LESS
6"Ø FOR 4 & 5 TON
Main Supply
Main Return
DDH
ODAD
SS
Out Door Air Pre-Filter in Hinged Grill
12x12 FILTERED INTAKE GRILL
MAIN ENTRANCE DOOR
SYSTEM FILTER
29


U.S. Department of Energy
Energy Efficiency and Renewable Energy
Building Technologies Program
Next Steps for Siesta Key Home
• Complete all work and commission the system
• Instrument and monitor starting ~March 2008
30


Thank You

Presentation by Joe Lstiburek

Joseph Lstiburek, Ph.D., P.Eng, ASHRAE Fellow

Building Science

Ventilation

presented by www.buildingscience.com

Why (Builder)? Risk-Durability
Risk-Comfort
Risk-Health

Building Science Corporation — Joseph Lstiburek 2

Why (Rest of Us)? Risk-Health
Comfort
Durability

Building Science Corporation — Joseph Lstiburek 3

Technology

Building Science Corporation — Joseph Lstiburek 4

Build Tight - Ventilate Right

Building Science Corporation — Joseph Lstiburek 5

Build Tight - Ventilate Right
How Tight?
What's Right?

Building Science Corporation — Joseph Lstiburek 6

Best

As Tight as Possible - with -
Balanced Ventilation
Energy Recovery
Distribution
Source Control - Spot exhaust ventilation
Filtration
Material selection

Building Science Corporation — Joseph Lstiburek 7

Air Barrier Metrics

Material	0.02 l/(s-m2) @ 75 Pa	
Assembly	0.20 l/(s-m2) @ 75 Pa	
Enclosure	2.00 l/(s-m2) @ 75 Pa	
		0.35 cfm/ft2 @ 50 Pa
		0.25 cfm/ft2 @ 50 Pa
		0.15 cfm/ft2 @ 50 Pa

Building Science Corporation — Joseph Lstiburek 8

Barriers - Policy	ASHRAE 62.2 HERS/RESNET
Barriers - Technology	ECM Supplemental Dehumid
Barriers - Cost	Exhaust $100 Exhaust + Dist $150 Supply + Dist $150 Spot + Ex/Sup + Dist $450 Balanced/ER $1,000

ASHRAE Standard 62.2 calls for 7.5 cfm per person plus 0.01 cfm per square foot of conditioned area

Occupancy is deemed to be the number of bedrooms plus one

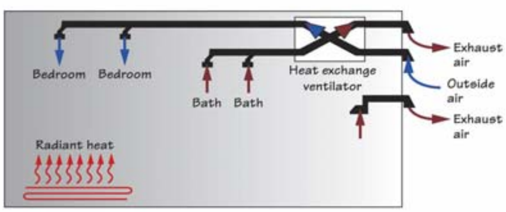
Occupant Rate + Building Rate

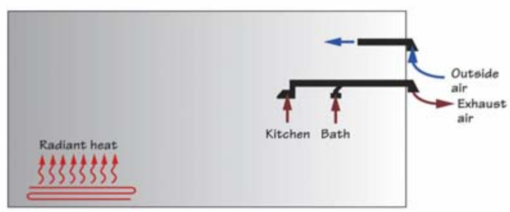
Q(v) = Ventilation Rate

Q(fan) = Q(v) • C(d)

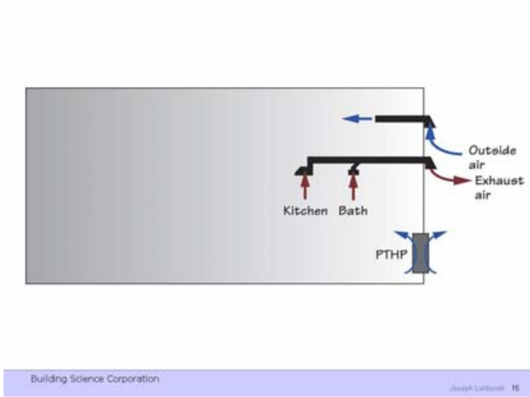
C(d) = Distribution Coefficient

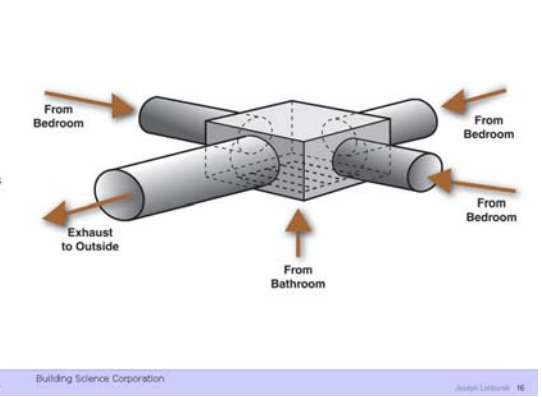
System Type	Distribution Coefficient (C_d)
Balanced ventilation, with central forced air distribution system or a fully ducted ventilation system	1.0
Unbalanced ventilation (Supply or exhaust), with central forced air distribution system having a minimum run time of 10 minutes per hour	1.25
Unbalanced ventilation (Supply or exhaust), with central forced air distribution system or multi-point exhaust or supply	1.5
All other systems	1.75

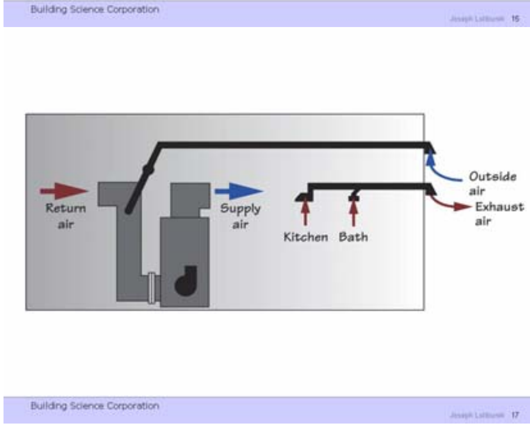


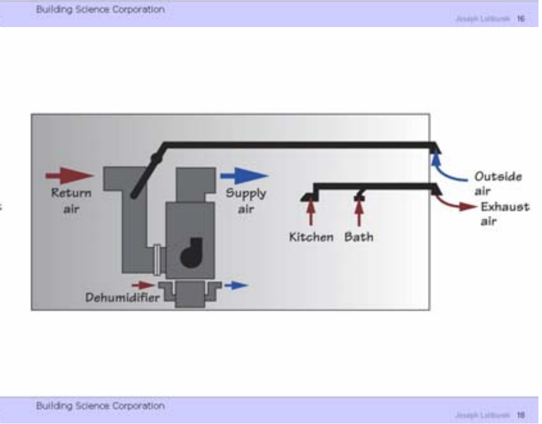


DRAFT FOR REVIEW

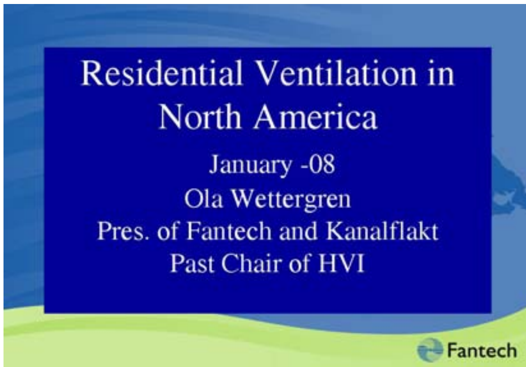

Outside air
Exhaust air
Kitchen
Bath
PTHP
Building Science Corporation
15

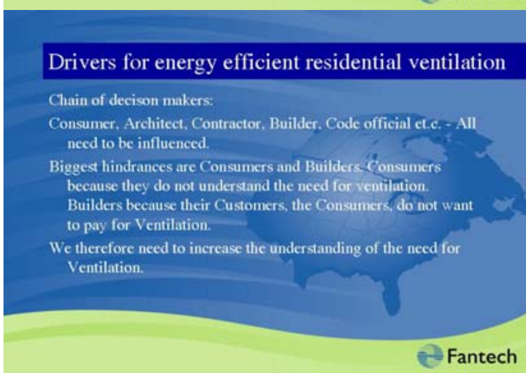

From Bedroom
From Bedroom
From Bedroom
Exhaust to Outside
From Bathroom
Building Science Corporation
16

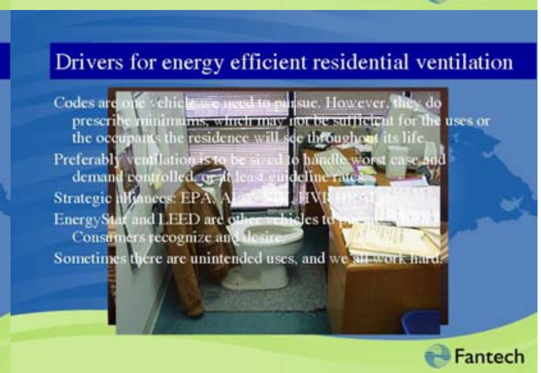

Return air
Supply air
Kitchen
Bath
Outside air
Exhaust air
Building Science Corporation
17

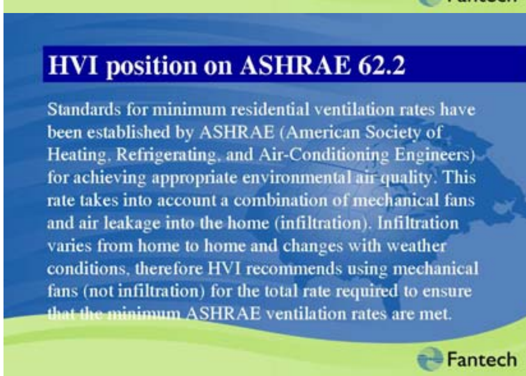

Return air
Supply air
Kitchen
Bath
Outside air
Exhaust air
Dehumidifier
Building Science Corporation
18

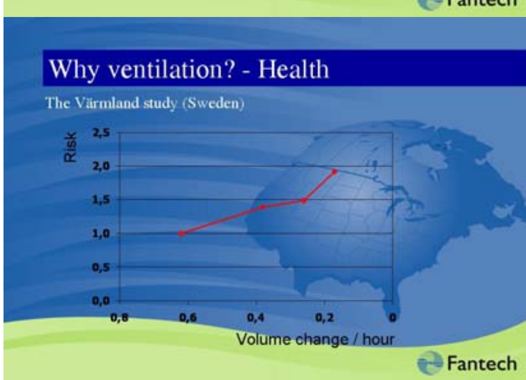
Presentation by Ola Wettergren

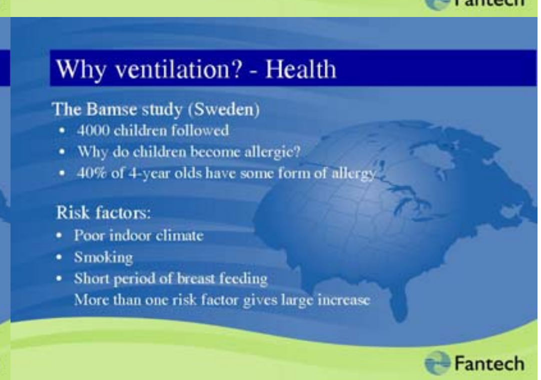


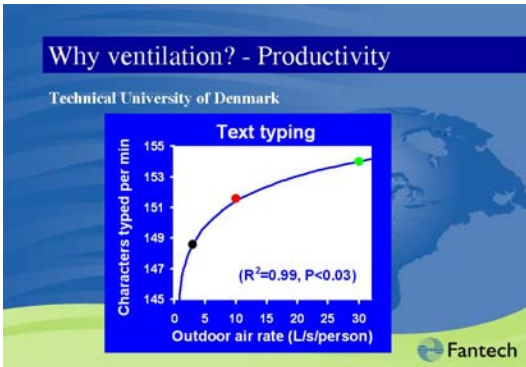




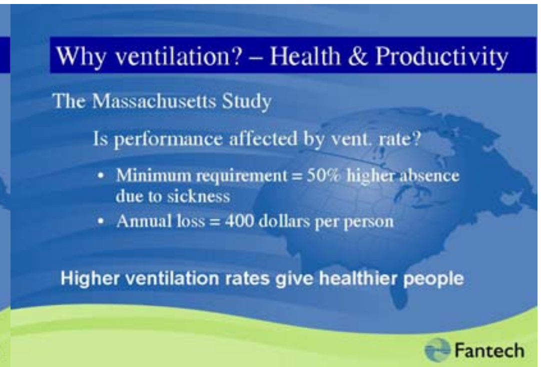




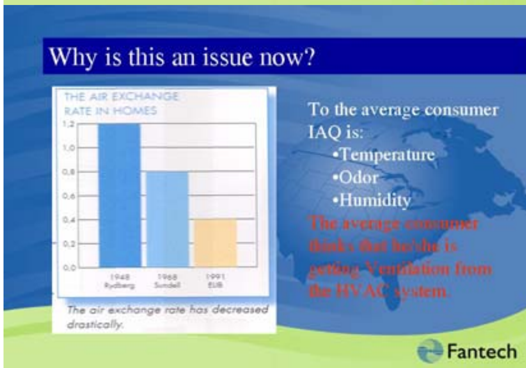




Why ventilation? - Productivity
Technical University of Denmark
Text typing
Characters typed per min
155
153
151
149
147
145
(R^2=0.99, P<0.03)
0 5 10 15 20 25 30
Outdoor air rate (L/s/person)
Fantech

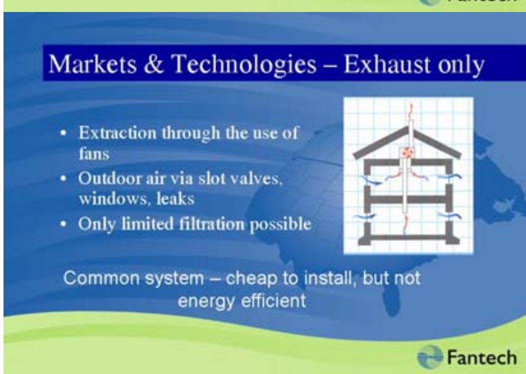


Why ventilation? – Health & Productivity
The Massachusetts Study
Is performance affected by vent. rate?
• Minimum requirement = 50% higher absence due to sickness
• Annual loss = 400 dollars per person
Higher ventilation rates give healthier people
Fantech

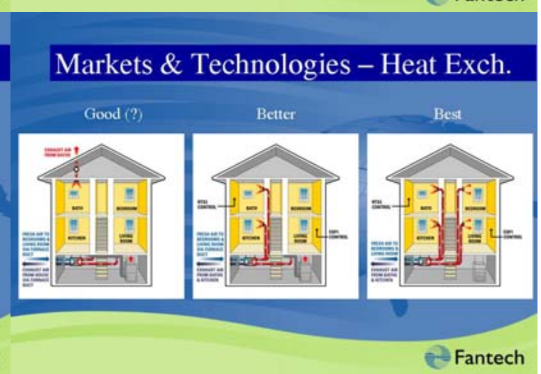


Why is this an issue now?
THE AIR EXCHANGE RATE IN HOMES
1948 Rydberg
1968 Sundell
1991 EUB
The air exchange rate has decreased drastically.
To the average consumer IAQ is:
•Temperature
•Odor
•Humidity
The average consumer thinks that he/she is getting Ventilation from the HVAC system.
Fantech

Markets & Technologies
Fantech



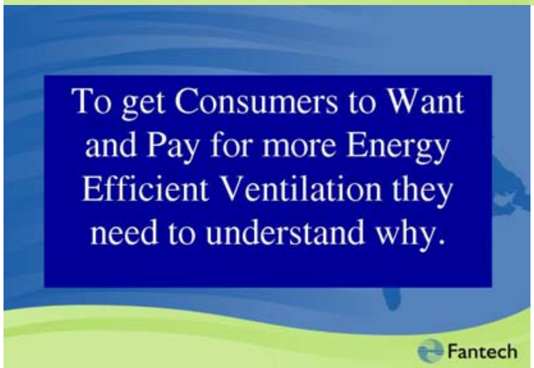
Markets & Technologies – Exhaust only
• Extraction through the use of fans
• Outdoor air via slot valves, windows, leaks
• Only limited filtration possible
Common system – cheap to install, but not energy efficient
Fantech



Markets & Technologies – Heat Exch.
Good (?)
Better
Best
Fantech


Technologies – Builders' Option
Fantech


Markets & Technologies – heat exch.
Rotary heat exchanger / Thermal wheel
Liquid-coupled heat exchanger / Run-around coil
Plate heat exchanger
Fantech


To get Consumers to Want and Pay for more Energy Efficient Ventilation they need to understand why.
Fantech

Presentation by Don Stevens

PHEC Research & Development

Barriers to Implementation of Energy Efficient Residential Ventilation

Don Stevens
National Research & Development Manager
Panasonic Home and Environment Co.
January 10, 2008

Drivers for En Eff Res Ventilation

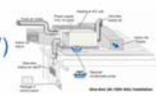
- Global warming/carbon reduction
- Poor IAQ in homes
- Rising cost of utilities
- Increased use of man-made construction products

Markets and Technologies

- Utility programs
- Energy Star
- LEED for Homes and other Green programs
- Single Family
- Low-Rise and High-Rise Multifamily
- New and existing homes and apartments

Markets and Technologies

- Fans (supply or exhaust)
  - Using less energy (as low as 5 watts)
  - Getting quieter (400+ HVI models < 1.0 sone)
- Integrated central systems
  - With airhandler (timer, HRV/ERV)
  - With dehumidifier
  - With water heater (HPWH)
- Balanced systems
  - ERV, HRV, other



Markets and Technologies

- DC motors
  - 4.7 watts @ 30 cfm
  - 5.2 watts @ 40 cfm
  - 6.6 watts @ 50 cfm
  - 7.6 watts @ 60 cfm
  - 8.9 watts @ 70 cfm
  - 11.3 wats @ 80 cfm
- Set continuous flow 30-70 cfm (62.2)
- Kick to high of 80 for settable time

Barriers to En Eff Res Ventilation

- Lack of consumer information
- Lack of designer information
- Lack of contractor information
- Perceived high first cost
- Perceived high operating cost

Lack of consumer information

- Consumers do not understand the need for residential mechanical ventilation
- IAQ is generally odorless, tasteless, and invisible to the occupant
- Consumers somewhat understand the intangible values of "Green" building but generally are hung up on reducing energy costs

Lack of consumer information

- Consumers think their HVAC system takes care of the Ventilation requirements
- Consumers think that any new electrical load is a negative and so must be avoided.
- Consumers are aware of outdoor pollution but not aware that the air in the home may be much worse

Lack of consumer information

- Consumer awareness is starting to improve but mostly because of press about mold damage and "sick building" issues

Lack of designer information

- The majority of residential building designs are not created or reviewed by an engineer or an architect and are often "value engineered" to minimize the first costs
- The majority of the residential architects were not trained in energy efficient design or the value of mechanical ventilation for residential buildings

Lack of designer information

- The **USGBC LEED** program has raised this awareness for nonresidential buildings and the hope is that the **LEED for Homes** program will do the same for residential building design
- The **EPA Energy Star Homes** program still does not require mechanical ventilation – it is just now offering an "IAQ Package" as an option

Lack of contractor information

- The building community is just now becoming aware of the need for mechanical ventilation
- The Model Codes from ICC still do not require mechanical ventilation in the kitchen, the bathroom (if a window is present), or the whole building for IAQ
- The Building America program and local programs have raised the awareness

Lack of contractor information

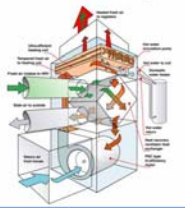
- Residential installation contractors still do not know how to properly install fans and so create lots of low-performing installations because of poor ducting and terminal devices, even when using excellent equipment
- Panasonic trying to improve this with online training for installers through "Panasonic Ventilation University"

Perceived high first cost

- Designers, builders, and consumers often are unwilling to try designed ventilation because of the perception that it will cost more upfront (and it often does)
- It is very difficult to quantify the avoided costs of poor IAQ as a way to offset the higher first cost

Perceived high first cost

- People often look for a dedicated system that costs a lot when an upgraded bath fan can do the job



Perceived high operating cost

- Consumers are concerned that their already-high utility bills will be impacted by the operating cost of the installed mechanical ventilation system
- Manufacturers try to minimize the added electrical load of the fan motor and/or the added HVAC load caused by the ventilation

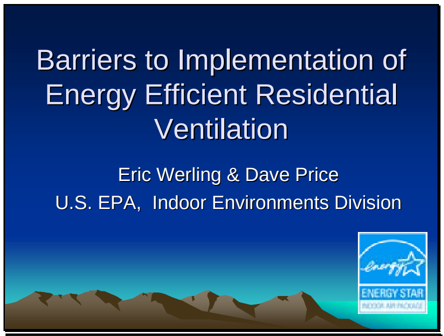
Perceived high operating cost

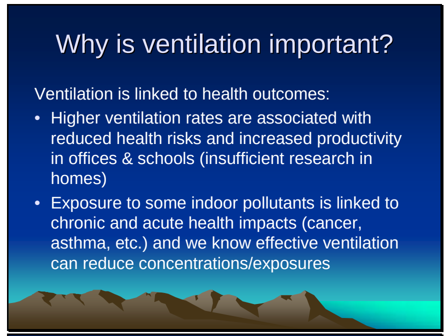
- Wide variety of ventilation approaches use different amounts of energy
  - Some equipment can provide the necessary ventilation with a continuously operating fan at 62.2 rates at 5-10 watts while others use the installed airhandler to ventilate intermittently at a much higher rate while drawing 300-500 watts
  - HRV/ERV products can recover some of the outgoing energy into the incoming air, but the higher pressure drop across the core uses more energy

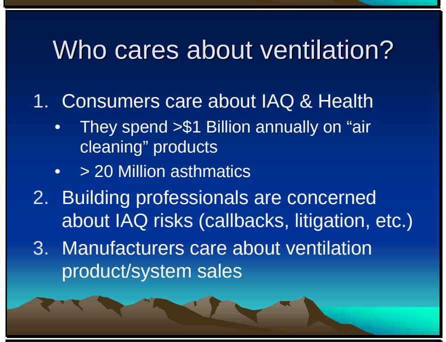
What do we need?

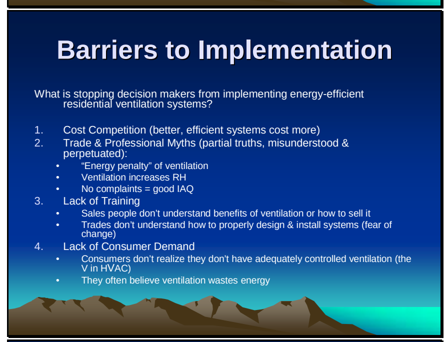
- INFORMATION
- INFORMATION
- INFORMATION
- INFORMATION
- INFORMATION

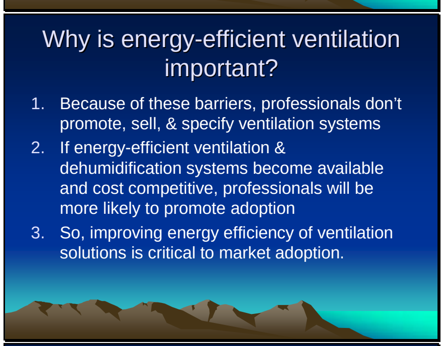
Presentation by Eric Werling

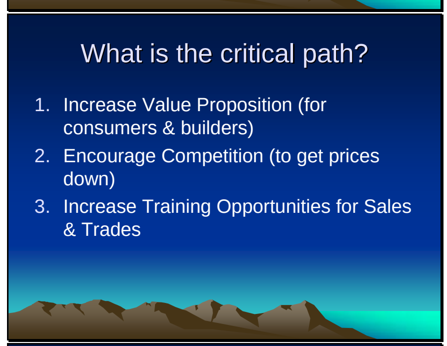


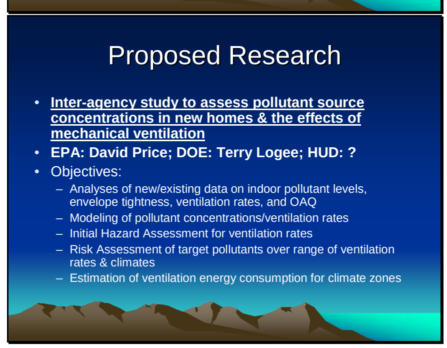




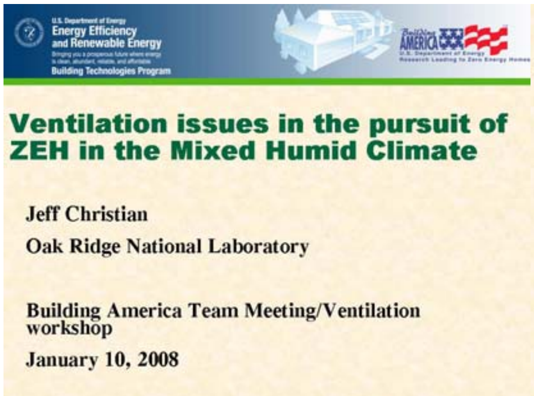


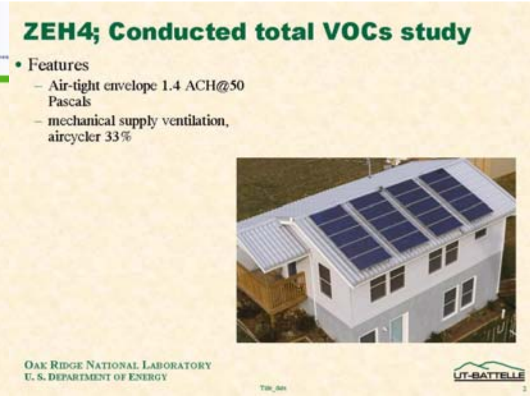


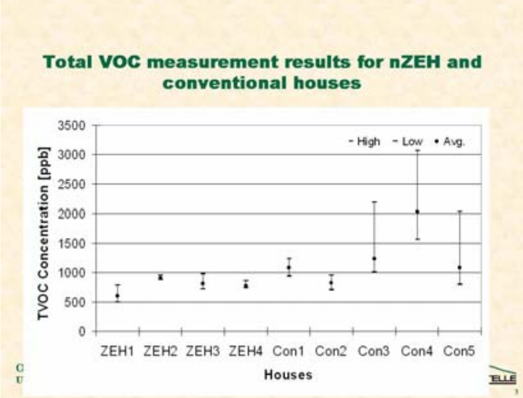


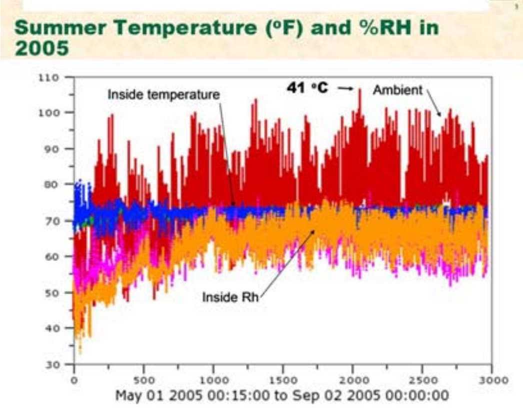


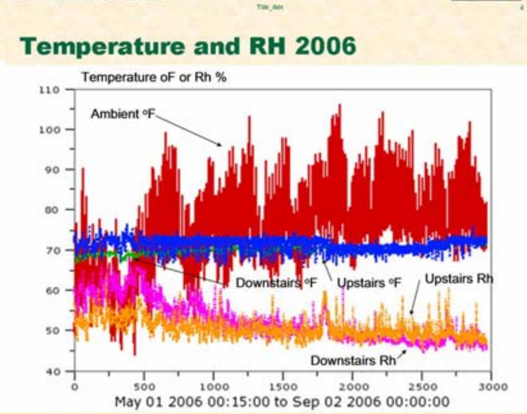
Presentation by Jeff Christian

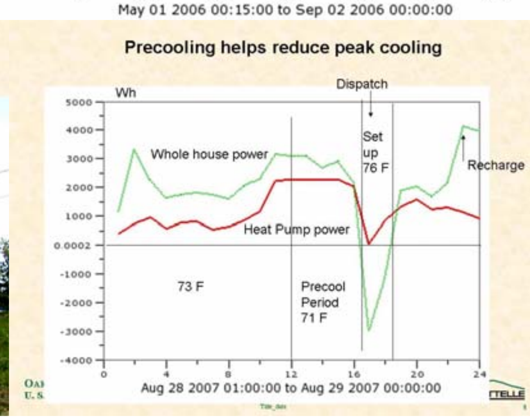




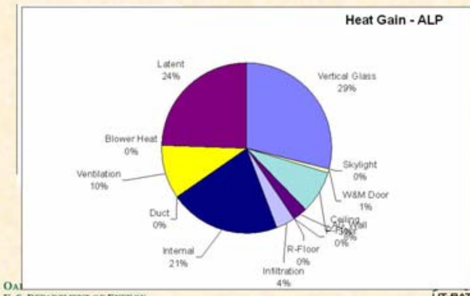






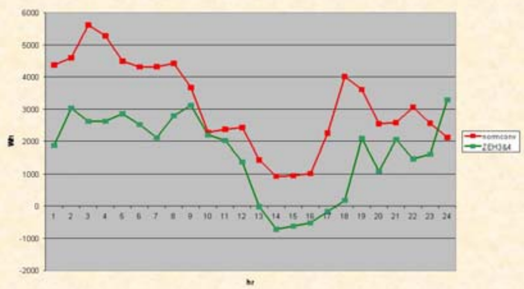


34% of Peak Cooling due to ventilation

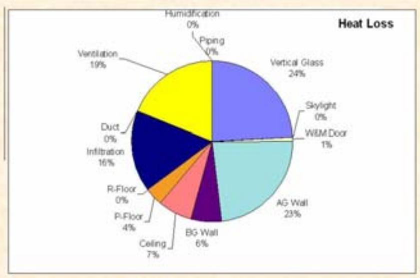


ZEH reduces Winter Peak Load by 50%

ZEH vs. Basehouse Peak January hourly load profile



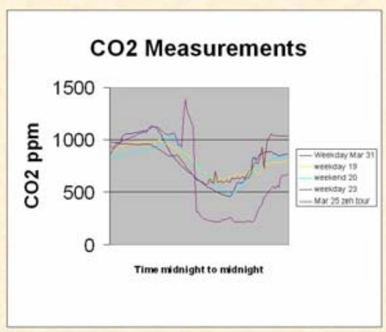
19% of Peak Heating due to ventilation



Like to examine the moisture impacts in houses with different levels of hygroscopic buffering

- Several papers at the Envelopes 10 conference
- Wood interiors have greater hygroscopic buffering potential

ZEH 2; collected CO_2 data for awhile



Leeds interest and sustainable material selection interest should

- Result in less source pollutants, 62.2 should give credit for homes that do a more thought full trim out with less air quality containments sources

Dehumidifying Heat Pump Water Heater

- Has potential to reduce latent loads in ZEHs
- Smart water heater recharge during high RH moments